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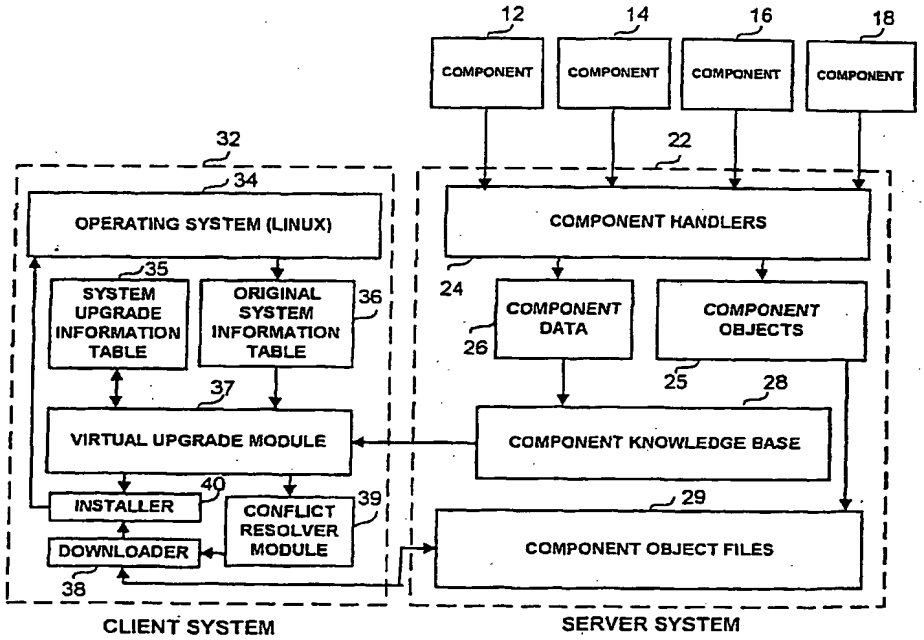

(57) Abstract: A system and method of software system upgrade simulation utilizing a collection of newly developed software modules or new version of existing software modules, information regarding the collection of software modules, and a specific rules language for supporting system managers. The system produces a dependency-conflict-free system configuration file thereby making available the option to system mangers to perform a conflict-free software system upgrade process.

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A VIRTUAL SYSTEM CONFIGURATOR SERVER FOR LINUX

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to an apparatus and a method for supporting computer system management, in general, and for providing assistance to system managers in the process of configuring, installing, compiling and upgrading a computer system, in particular.

DISCUSSION OF THE RELATED ART

Computer systems are a collection of computer programs. Modern computer systems are modular in the sense that are designed and actualized using as building blocks a plurality of functionally interconnected software modules. The software modules that constitute the computer systems are computer programs as well, communicating in the standard manner of computer programs by passing arguments.

Requirements from modern computer systems are extremely demanding, therefore a contemporary computer system consists of a remarkably complex set of instructions. Apart from the conventional functions routinely expected from an operating system portion of the computer system such as memory management, file control, I/O commands, buffering, process scheduling and the like, computer systems today are additionally required to function in complex operational settings such as a multi-user environment. The support of a plurality of diverse and sophisticated services such as multitasking and communications became a standard requirement and so did the demand to support a vast and steadily growing number of sophisticated interfacing methods to increasingly advanced hardware devices. As a result prevalent operating systems

are highly complicated structures having made up of a multitude of different software modules in a vast number of different combinations.

Following the accelerated advances and improvements in computer-related technologies and the development of new technologies for the same, the changes required in the functionalities of the computer systems as well as addition of new functionalities thereof became a prerequisite of an operative computer system. Consequently systems are constantly growing in size and complexity in correspondence with the growth in the number of software modules that construe a state-of-art computer system. This "horizontal" growth in the number of software modules is further augmented by a "vertical" growth in the number thereof. When a software module is improved or changed, the existing module is preferably replaced with the improved one. In many cases it necessitates corresponding replacement of various other software modules that are logically interconnected with the replaced module. The new module to be installed is defined as a "new version" (typically designated with a number) and the module to be replaced is defined as the "old version" (typically designated with a lower number). Sometimes whole clusters of functionally interconnected modules are improved simultaneously inducing thereby the preferable replacement of the cluster consisting of "old version" modules. Furthermore, it will be readily perceived by those skilled in the art that for diverse reasons the necessary replacement process is not always carried out routinely.

Computers have become less expensive and the use thereof became widespread. Consequently a vast number of users have been exposed to computers and computer systems. The majority of these users are rarely characterized by being trained and experienced computer professionals. Accordingly, system management to a great extent is being done by persons whose expertise in the internals of computer operating systems is hardly sufficient to deal with the complexities of a necessary system upgrade or an urgent installation of a new set of hardware device drivers.

Typically, upgrading a computer system involves either adding new components to the ones already in place or replacing existing components by recently developed or improved versions thereof. The process involves collecting the appropriate components from one or more sources (commercial software companies, independent developers, distribution sites on the Internet or any combination thereof) and installing the components by means of appropriate utility programs. The installation utilities could be part of the original computer system or could be supplied by the vendor and/or the developer.

The specific operation of altering a software configuration involves installation, uninstallation, replacing of software components or any combination thereof. For the purposes of a clearer description all types of software configuration changes will be referred to as "upgrading" in the text of this document.

The majority of the available installation utilities operate in a basic fashion. The components of a new type to be installed are inserted and added to the computer system whereas new versions of existing component types overwrite the previous versions rendering them thereby inoperative. The computer system configuration files are updated accordingly and the original configuration files are removed. Installation utilities of a more advanced type include some operational safety measures such as storing the deleted components in specific storage areas, saving original configuration files and providing a list of actions performed. Some specialized utilities check for inter-component dependencies and provide warnings about possible incompatibilities between the original system configuration and the set of components about to be installed. In the face of these unfavorable circumstances the utility programs typically display a warning message, discontinue the upgrade process and permit the system manager to solve the problem in a conventional manner. Solving the problem in such a manner may require a extended time-period as it may involve the reading of a large amount of documentation before proceeding, a plurality of requests for software support

from the appropriate vendors, waiting for answers from the corresponding vendors and the like.

It would be evident to those skilled in the art that considerable technical knowledge and expertise is needed for the computer system upgrade although some of the requisite steps are quite straightforward and satisfactory means is provided for the assistance thereof. In contrast, for the most difficult part of the upgrade process i.e., for configuring the system, no comprehensive automatic tools exist as yet.

It will be also obvious to those skilled in the art that there is a long felt need for a comprehensive, preferably automated system management support conducive to fast, solid, efficient and trouble-free system upgrade. There is an urgent need specifically for an advanced service designed to aid and assist system managers in the exacting tasks related to the maintenance of complex and dynamically evolving contemporary computer systems.

SUMMARY OF THE PRESENT INVENTION

One aspect of the present invention regards a central server system on which a software components upgrade simulation process is based. The central server is having a storage device, an I/O device, a communication device, and an operating system. The virtual system upgrade method consists of gathering information related to software components, researching said information, collecting and storing relevant component objects and associated information, encoding the dependency relationships of the collected components into a model of dependency rules, storing said dependency rules, validating said dependency rules and making available to system managers of connectable client system to utilize the collected, stored and encoded information to perform a conflict-free virtual system upgrade configuration and consequently depending on the results a software system upgrade operation.

A second aspect of the present invention regards a virtual system configuration system based on a central server system for the use of system managers of client system connected thereto. The central server system is having a storage device, an I/O device, a communication device, and an operating system. The virtual system configurator consists of a knowledge database, a component object database, a user preferences table, a rules language module, a component input module, a component validation module, a client requests and queries handling module and a knowledge base handler module.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood and appreciated more fully from the following detailed description taken in conjunction with the drawings in which:

Fig. 1 is a block diagram of the computerized environment in which the virtual system configurator is operating in accordance with a preferred embodiment of the present invention;

Fig. 2 is a simplified block diagram of the configuration of the virtual system configurator server device in accordance with a preferred embodiment of the present invention;

Fig. 3 is a simplified block diagram showing the various tables the knowledge base device consists of, in accordance with a preferred embodiment of the present invention;

Fig. 4 is a tree-like representation of the version tree, in accordance with a preferred embodiment of the present invention;

Fig. 5 is an illustration of the Rule tables structure and operation in accordance with a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The preferred embodiments of the present invention are in the context of the Linux environment. Linux is a full-featured UNIX-like computer system that was designed to provide personal computer users a free or very low-cost operating system comparable to the traditional and usually more expensive UNIX systems. Linux has a reputation of a very efficient and fast-performing system. Linus Thorvald of the University of Helsinki in Finland has created the Linux kernel, the central part of the operating system. To complete the operating system, Linus Thorvald and other team members made use of system components developed by members of the Free Software Foundation for the GNU project

Unlike traditional proprietary computer systems, Linux is publicly open and extensible by contributors. Because it conforms to the POSIX standard user and programming interfaces, developers can write programs that can be ported to other operating systems. Linux is distributed commercially by a number of companies.

As the source code was made freely available and further development by others was widely encouraged, a massive, worldwide development is pursued today by a great number of companies, programmer teams and individuals independently or in cooperation with others. As a result of this extensive activity, a multiplicity of new drivers, modules, packages, and applications are written and distributed for Linux constantly. The new systems, versions, and components written for Linux are all potentially installable and operative in every Linux installation circumscribed only by the processor type.

Linux is a powerful and popular operating system and it is widely used on personal computers. It will be readily perceived that a proposed solution designed to support the management of computer systems will be particularly suitable for the Linux environment. The present invention overcomes the disadvantages of the prior art by proposing a novel method and a system, which provides an automated or a semi-automated mechanism to the purpose of altering

a specific software configuration in a computer system by changing the combination of software components said system consists of. The present invention provides an advanced method and system that facilitates the simplification and the automation of the upgrade process when installing components, thereby practically eliminating the possibility for incompatibilities to occur in the course of the upgrade process in a Linux environment. To achieve its objectives the present invention proposes the use of a Virtual System Configurator Server for Linux.

A central server-based knowledge base is created and maintained. The knowledge base ideally includes the entire set of available Linux-compatible software entities such as kernels, utilities, compilers, packages, patches, device drivers, configuration files and the like. All the above mentioned entities will be referred to as "component objects" in the text of this document. Typically component objects are associated with information units describing the component object's characteristics. The information units are received along with the component objects or could be retrieved separately. Component information will be referred to as "component data" in the text of this document.

The appropriate components and component suppliers thereof are identified. The suppliers could be software companies, individual developers, Internet software distribution sites and the like. The components and the component data associated therewith are collected, retrieved and stored into the memory device of the central server device using various electronic transmission means such as downloading from an Internet site. The component supplier, component object and component data identification process, the component object and the component data collection and reception is an ongoing operation on the server device. Therefore the sets of the assembled component objects and related component data on the server device are being constantly extended and continuously updated. Using related component data the component objects and their relationships are interrogated or researched; the results are encoded and stored on the memory device of the server system in a structured pattern onto a

specially designed knowledge base, which is subsequently validated by repeated testing of the component relationships. The research and validation processes are also continuous. Consequently at any given point in time the knowledge base consist of state-of-art component objects and an up-to-date abstract model of all the existing interdependencies thereof. Typically, the component object files include the most recent component objects available and the latest versions of the existing component objects.

Users of client systems operating in a Lunix environment and requiring a system upgrade connect intermittently to the central server-based knowledge base. The server system provides a specially developed virtual system configurator software that enables the users to export the knowledge base from the server, resolve the conflicts resulting of the virtual system upgrade, download and install the pertinent component objects and perform a real system upgrade. Typically, the process is initiated by user request.

It will be easily perceived by one skilled in the art that in an another embodiment of the invention the above-described process could be automatic or semi-automatic according to the user's decision.

Referring to Fig. 1 there is shown constructed and operative in accordance with the preferred embodiment of the present invention the computerized environment in which Virtual System Configurator Server system 22 is operating. Components 12,14,16,18 are retrieved, entered into server system 22, stored on a memory device on server system 22 and processed by component handlers 24. Component objects 25 are stored into component object files 29 and the associated component data 26 is inserted into Component Knowledge Base 28. Component handlers 24 also perform validation procedures on component data 26 stored in knowledge base 28. Using an expressly designed rules language the functional dependencies of the component objects are encoded into an abstract model representing inter-component dependency rules. The encoded rules are inserted into knowledge base 28 creating new entries or updating the suitable

entries of knowledge base 28. The detailed description of the various tables, of the rules language and of server 22 operation will be set forth hereunder in association with the following drawings.

Client system 32 is intermittently connected to server system 22. Client system 32 consists of an operating system 24, an original system information table 36, a system upgrade information table 35, a Virtual Upgrade module 37, a Conflict Resolver module 39, a Downloader module 38 and an Installer module 40. In the preferred embodiment of the invention the operating system 34 is a Linux kernel-based system. Original system information table 36 mirrors the current system configuration. System upgrade information table 35 comprises the list of component objects to be installed, uninstalled or upgraded by user request. Virtual upgrade module 37 performs the requested virtual upgrade utilizing knowledge base 28 of server system 22. Virtual upgrade module 37 activates conflict resolver module 39 to check and resolve all the conflicts arising from the virtual installation of the requested component objects in conjunction with the system upgrade information table 35 by manipulating original system information table 36 according to the dependency rules retrieved from knowledge base 28. One or more virtual configuration files are created and tested. If the resulting virtual configuration files are conflict-free the installation of the components is confirmed, downloader module 38 downloads all necessary component objects from component object files 29 of server system 22 and installer module 40 installs the component objects onto operating system 34.

Server system 22 provides the information necessary for a virtual system upgrade according to client systems 32 requests through knowledge base 28. Server system 22 also provides the component objects needed for a given upgrade request. Server 22 further provides diverse services for client systems 32.

It will be appreciated by those skilled in the art that there are other ways to implement the proposed invention. In other embodiments of the invention different tables and methods could be used. The present invention is not limited to the specific mode of operation presented.

Referring now to Fig. 2 where a more detailed illustration of server system 22 software configuration is shown. Server 22 contains a component object and component data input module 63, a component validation module 56, a rules language module 58, the knowledge base 28, the component object files 80, a client requests module 76, a client queries and update module 70, a client preferences module 72, a client preferences table 73, a knowledge base handler module 74, an auto-update module 82, an auto-download module 84 and an auto-notify module 86.

The process of creating and maintaining knowledge base 28 is divided into four distinct but logically related stages or activities: (a) component intelligence gathering, (b) component interdependency research, component object and component data input, and (c) rules validation.

Component intelligence gathering 52 and component research activities are performed off-line by special teams. The component intelligence gathering team 52 handles all the activities relating to the retrieval of the entire set of available and operative Linux components and the entire set of available intelligence thereof. All the existing types of components are collected: hardware, software, kernel, RPM (RedHat Package Management) packages, distributions, patches, utilities, editors, compilers, command interpreters, commercial applications, system tools, servers, network modules, file-systems, games, development tools, graphical tools, programming languages, configuration files, interfaces, browsers and the like.

It will be readily perceived that each and every component could have a number of different versions and releases. For instance, the Vim editor used for text editing in UNIX-compatible systems could have two releases (Vim4 and Vim5) and the Vim5 version could have three versions (Vim5.1, Vim5.2 and Vim5.3). Components could be functionally related, for example in software packages comprising a plurality of software modules. Functionally related

components designed to work in close interdependencies therefore meant to be installed together.

Component data depict component object characteristics or component object attributes. When a component object is retrieved, the associated component data is inserted into knowledge base 28 by component object and component data input module 63.

The Component research team 54 handles all the activities relating to the analysis and organization of the component data received by component intelligence gathering team 52. Interconnectedness, interrelationships, interdependency rules such of "component 1" needs "component 2" and "component 25" can work with "component 44" or with "component 45" are studied and encoded into a formalized pattern. The component data is examined, scanned, analyzed, indexed, organized and stored by component object and component data input module 63 in rules table 62 and in vtree 60 in knowledge base 28 that on the memory device of server 22. Component validation module 56 using the component data retrieved by the intelligence gathering team 52, analyzed and organized by the component research team 54, and stored via component object and component data input module 63, runs validation processes on knowledge base 28 using rules tables 62 in conjunction with vtree 60 and the configuration files.

Knowledge base 28 comprises a Vtree (Version Tree) Database 60, a Rules Database 62, a Links Table 64, a Linux Update Modules (LUM) table 66 and a Stamps table 68. Knowledge base 28 and the tables incorporated therein will be described in detail hereunder in association with the following drawings.

Client request handler 36 receives and processes user requests from respective client systems 32. The requests are transmitted from the client systems 32 by means of conventional communication devices such as a modem, communication lines and communication software. Client requests handler 36 activates the appropriate client request modules. Client queries handler 30 accepts and processes query requests against Vtree 60 in knowledge base 28. Client

preferences module 72 is provided to respond to client systems 32 requests for client preferences table 73 updates. Knowledge base handler 74 is responsive to the client systems 32 requests to transmit all or parts of knowledge base 28 to the respective client systems 32 to be used in a user-initiated client system-based virtual system configuration process.

Auto-Download module 84 automatically downloads relevant component objects from component object files 80 in conjunction with the client preferences stored in client preferences table 73. Auto-notify module 86 responds to specific user preferences stored in client preference table 73 in conjunction with Vtree 60 by transmitting notices to the respective client systems 32 with regard to the availability of new components such as kernel patches.

Virtual System Configurator Server system 22 preferably incorporates all the necessary component objects for a required computer system upgrade in a Linux environment. Server system 32 also preferably incorporates the entire set of the requisite component characteristics or component data for a virtual system configuration process in a Linux environment. Server system 22 further develops and dynamically maintains a set of rules associated with the component objects that provides vital information about component object interdependencies.

It will be appreciated by those skilled in the art that in a different embodiment of the present invention a different mode of operation could be used. The present invention is not limited to the specific mode of operation presented

Referring now to Fig. 3 there is shown constructed and operative in accordance with the preferred embodiment of the present invention, Knowledge Base 28. Knowledge Base 28 is a collection of interlinked data structures designed to provide control information for the virtual system configuration process. Knowledge Base 28 comprises a Vtree (Version Tree) Database 60, an Xor rules table 61, an Add-Remove Rules table 63, a Links Table 64, a Stamp table 67, a Stamp Rules table 69, and a Linux Update Modules (LUM) table 66. The functionalities of the tables are described next.

Vtree database 60 consists of component data records associated with the component objects that are stored in component object.files 80 of Fig 2. For each component object one or more component data record is created and inserted into Vtree 60 by component intelligence module 52 of Fig. 2. There are several types of components such as hardware type, kernel type, software type and the like. Each type could have several subtypes for example, a component of the hardware type could have as subtypes; ISA (Industry Standard Architecture) cards, ISA PnP cards, Serial ports and the like. Each subtype in turn could have several subtypes of its own for example a hardware type component ISA cards subtype could have subtypes of its own like: Ethernet, SVGA (Super Video Graphics Array), Sound, Modem and the like.

In the preferred embodiment of the invention, vtree 60 is organized hierarchically i.e., in a tree-like manner and held in a tree-like data structure. Some of the fields vtree 60 consists of have designations such as node id or father id; concepts that are typical to tree-like data structures. Therefore for the purpose of a clear understanding of the present invention, the tree abstraction and associated concepts thereof will be briefly explained next.

Data structures called trees are known in the art. When information that is classified by breaking a whole into parts, and repeatedly breaking the parts into subparts, it is natural to represent the classification by a true structure. A tree has a single starting point called the "root" of the tree. In general an element of a tree is related to particular elements at the next lower level of the tree (as a parent related to children in a family tree). Some elements have no children. Because the branches do not merge, from every element of a tree one can trace a unique path back to the root. A tree is composed of nodes and edges. The nodes are any distinguishable objects at all, for example, component data records. Nodes can have descendant nodes or children. Nodes with descendant nodes are called the father nodes of descendants thereof. Nodes belonging to the same father node called brother nodes or sister nodes. An edge is an ordered pair of nodes i.e., a

connection between two component data records. A leaf is a node with no children nodes or descendant nodes.

Returning now to Fig. 3 where a block diagram of knowledge base 28 is shown. A component data record stored in Vtree 60 database consist of the following fields: (1) a node id or component id, (2) a component name, (3) a node type, (4) a father id, (5) a next brother id, (6) an install script, (7) an uninstall script, (8) a version number, (9) a release number, (10) an update module number, (11) an icon pointer, (12) a component name for display, (13) a component description and (14) a stamp index. The contents of the fields are described next.

Node id (1) is equivalent to component id that uniquely identifies a component object. Component intelligence module 52 of Fig. 2 designates all received components using a hierarchically organized system of numbering used to express the hierarchical relationships between component objects of the same type or subtype. For example, component object "kernel" could be given the number 1000 and component object "kernel patch" which is a subtype of "kernel" could be given the number 1010. Component name (2) is the component object name such as "compiled kernel" or "rpm". Component node type (3) indicates the type of the tree node such as root, leaf, node and element. Father id (4) indicates the node id of the parent node or of the node immediately above the present node in the tree. Next brother (5) indicates the next node in the tree with an identical parent node to the current node. Install script (6) is a pointer to the specific installation script used for the upgrading process of the component object. Uninstall script (7) is a pointer to the specific uninstallation script used in the upgrading of the component object. Update module number (8) points to the appropriate entry in Linux Update Module table 66. Pointer to icon (9) is a pointer to the icon file associated with the component object. Name for display (10) is the name of the component object to be displayed to the users. Description (11) is a text to be displayed to the users. Stamp index (12) is a pointer to the latest stamp put on the record.

It should be appreciated that in a different embodiment of the present invention other useful fields could be used such as manufacturer identifier and the like. The present invention is not limited by the above description. Other useful information to be placed in the database could be contemplated by a person skilled in the art.

Xor Rules table 61 and Add-Remove Rules table 63 consists of rules provided for checking the dependencies between one or more component objects. The rules records in the Xor rules table 61 and the add-remove rules table 63 are created and maintained utilizing the rules language. Xor Rules table 61 consists of two fields: (1) a rule index and (2) a component number. Xor rules table 61 functionality will be described hereunder in association with the following drawings. Add-remove rules table 63 consists of three fields: (1) a component number (2), a bracket index (3) a component number that is needed. Add-remove table 63 functionality will be described hereunder in association with the following drawings.

Links table 64 provides links between different leaves of Vtree 60. The purpose of the links is to connect two groups of components; for example a kernel version and a fixing patch thereof. The fields of links table 64 are (1) a link index, (2) id of the first node to be connected, (3) id of the second node to be connected, (4) a link type and (5) a version stamp.

Linux Update Module table 66 points to the installation file to be used during installation. Linux Update Module 66 consists of two fields: (1) installation file number, and (2) the location of the installation file.

Rule Stamps table 69 holds a list of rule stamp types such as add-stamp, remove-stamp, and xor-stamp. Rule stamp table 69 consists of two fields: (1) the id of node, and (2) the rule stamp type.

Stamp Table 67 holds the historical list of all the stamps applied to Vtree 60. Stamp Table 67 consists of the fields: (1) a stamp index, (2) a date issued, and (3) an issuer of the stamp.

The Rules tables, Xor rules table 61 and Add-remove rules table 63 comprise the inter-component dependency rules. The dependency rules records are created utilizing the rules language. Therefore the operation of the rules tables will be described hereunder in association of the rules language and the following drawings.

In the preferred embodiment of the present invention each component data record represents an abstract component type such as "hardware", "software", "kernel", one or more abstract component subtypes such as "isa cards", "pci cards", 'kernel parameters", "kernel patches" or an non-abstract component subtype such as "PATCH-QIC8-TAPE", "CONFIG_IRDA", "EMACS3.1" and the like. The types and subtypes are organized hierarchically and stored into the nodes of a tree-like data structure. The nodes are interconnected by edges linking the nodes in such a manner that the node containing component type "kernel" is connected to a descendant node thereof containing component subtype "kernel_ base" that in turn connected to a descendant node containing component element "2.2.1", to another descendant node containing component element "2.2.2" and still to another descendant node containing component element "2.2.4".

Referring now to Fig. 4 which is a schematic presentation of vtree 60, organized as a tree-like data structure. The root node 110 is located on the top of tree. Root 110 has three descendants or "children"; a node containing hardware component type 111, a node containing kernel component type 112 and a node holding RPM (Red Hat Package Management) component type 113. The tree node containing hardware component type 111 has three children nodes or descendant nodes: a node holding the record ISA cards component subtype 114, a node holding the record of PCI (Peripheral Component Interconnect) cards component subtype 115 and a node holding the record of serial ports component subtype 116. The node holding the record of hardware component type 111 is the

"father" of the nodes 114, 115, and 116. Node 114 has two "brothers/sisters"; node 115 and node 116. Tree node 114 containing the record of component subtype ISA cards has three descendant nodes; node 117 containing component subtype record Ethernet, node 118 for component subtype record SVGA and node 120 containing component subtype record Sound. It will be easily perceived that the hierarchical organization of a tree-like data structure is suitable for the classification of a set of software entities divided into types and subtypes.

It will be apparent to one who skilled in the art that in another embodiment of the present invention the component data records could have been stored into a different data structure such as a linked list and the like.

Xor rules table 61 and Add-remove rules table 63 comprise the dependency rules. The dependency rules records are created utilizing the rules language. Therefore the operation of the rules tables will be described next in association of the rules language.

The rules language defines the dependency relationships between two or more component objects in terms of distinct components, component sets, component choice-sets, rules sets, need-rules sets and xor rules-sets using logical operators and dependency operators. Distinct components in the rules language are integer numbers uniquely identifying a component object, for example 1075. The identifying integer number can be prefixed by the "NOT" operator to indicate that that the component is not installed, for example NOT 1025. Formally, a distinct component as an entity in the rule language can be defined as:

<COMPONENT>:

integer number or NOT integer number.

Component sets are a group of integers representing component objects connected with the AND logical operator. For example: 835 AND 1025 AND 4500 indicates that the component objects included in the component set are all installed. Formally, a component set as an entity of the rule language can be defined as:

<COMPONENT SET>:

<COMPONENT> or <COMPONENT> AND <COMPONENT SET>

Component choice-sets are a group of integers representing component objects connected with the OR logical operator. For example 3450 OR 6700 OR 1201 indicates that one of the component objects included in the component choice set is needed in installing a dependent component. Formally, a component choice-set as an entity of the rule language can be defined as:

<COMPONENT CHOICE>:

<COMPONENT> or <COMPONENT> OR <COMPONENT CHOICE>

Rules-sets consist of a component choice-set connected with the AND logical operator to an another rule-set. For example, (2300 OR 2306 OR 2077) AND (900) indicates that in order to install a specific component object successfully, component object 900 and one of the component objects that are the members of the expression in the brackets are needed to be installed as well. Formally, a rule-set as an entity of the rule language can be defined as:

<RULES SET>:

<COMPONENT CHOICE> or <COMPONENT CHIOICE> AND <RULES SET>

Need rule-sets consist of a component set connected by the NEED dependency operator to a rule-set. . For example, (2300 AND 2306) NEED (900 OR 901 OR 902) indicates that in order to be installed successfully, component object 2300 and component object 2306 needs component object 900 or 901 or 902 to be installed as well. Formally, a need rule-set as an entity of the rule language can be defined as:

<NEED RULE>:

<COMPONENT SET> NEEDS <RULES SET>

Xor rule-sets consist of an XOR logical operator and a component choice-set. For example, XOR (950 OR 952 OR 978) indicates that in order to install successfully a specific component object only one of the component

objects in the component choice-set can be installed. Formally, a Xor rule-set as an entity of the rules language can be defined as:

<XOR RULE>:

XOR <COMPONENT CHOICE>

Fully developed rule language expressions can take one of the following two patterns:

<EXPRESSION>:

<NEED RULE> or <XOR RULE>

It will be apparent to one who skilled in the art that in another embodiment of the present invention the rules language could contain additional entities and additional operators.

Referring now to Fig. 5 where the detailed structure of the rule tables is shown with accompanied examples fully developed. Add-remove table 63 consists of three fields: (1) node-id, (2) cond-index, and (3) item-id. Node-id (1) is a unique number identifies a component object to be installed. Cond-index (2) is an index denoting a specific bracket in the expression that contains a component object number that needed to be installed in order for the component object identified by node-id (1) could be installed successfully.

Component object "tkcvs" is a graphical application for version control of development projects written in the "tcl" programming language. Graphical extension module "tk" is used typically by "tcl". "Tkcvs", "tcl" and "tk" are all component objects stored in the component object files 80 of Fig.2. "Tkcvs" is identified by the integer 100, "tk-8.0" i.e., "tk version 8.0" by the integer 80, "tk-8.1" by the integer 81, "tk-8.2 by the integer 82. "Tcl-8.0" is identified by 68, "tcl-8.1" by 69 and "tcl-8.2" by 70. The component data of all the discussed components is stored in hierarchical order in vtree 60 of Fig.3. In order to install "tkcvs" successfully on a specific client system 32 of Fig. 1 other component

objects on which "tkcvs" is depending have to be installed as well. Component research module 54 obtains the following dependency rule in human language:

Tkcvs component object needs tk component object with a version number greater or equal to 8.0 and tkcvs needs tcl component object with a version number greater or equal to 8.0.

The rule in human language is transformed by research module 54 using rule language module 58 of Fig. 2 into the rule language expression:

TKCVS NEEDS {(TK8.0 OR TK8.1 OR TK8.2) AND (TCL8.0 OR TCL8.1 OR TCL8.2)}

The expression is a need-rule comprising a distinct component object identifier, a NEED operator, and a rules-set. The rules-set comprises two component choice-sets connected with the AND operator. The component choice-set comprises of distinct component object identifiers connected by the OR operator. Therefore the expression is consistent with the terminology of the rules language.

The expression is encoded and inserted into add-remove rules table 63 in the format shown in box 101. "Tkcvs" is identified by the number 100 therefore the field node-id is set to the same number."Tk8.0" is identified by the number 80 therefore the field item-id is set to the same number. "Tk8.0" is contained in the first bracket of the expression therefore the field cond-index is set to 1. In the next two records the fields node-id and cond-index are replicated and item-id is set to the value of 81 that is the identifier of component object "tk8.1" and to the value 82 that is the identifier of component object 'tk8.2" respectively. In the fourth, fifth and sixth line the value of node-id is replicated whereas the field cond-index set to the value of 2 to denote the second bracket in the expression. The field item-id is respectively set to 68,69, and 70 that denote the component objects "tcl8.0", "tcl8.1" and "tcl8.2" respectively.

The NEED operator is assumed, as every need-rule set comprises a NEED operator by definition. In box 104 there is shown the detailed underlying logical syntax of the add-remove rules table.

Consequently when a virtual installation of application "tkcvs" will be attempted, conflict resolver module 39 of Fig. 1 will interrogate original system information table 36 on client system 32 whether the component objects on which "tkcvs" is depending are installed in the operating system 34 of client system 32. If none of them is installed then before successful installation of "tkcvs" the appropriately chosen component objects from component object files 80 of server system 22 will be downloaded by downloader module 38 of client system 32 and installed alongside "tkcvs" by installer module 40 of client system 32.

Still referring to Fig. 5 where the detailed structure of the rule tables is shown with accompanied examples fully developed. Xor rules table 61 consists of two fields: (1) cond-index, and (2) item-id. Cond-index (1) is a unique number that identifies a group of component objects that for various reasons are not permitted to operate simultaneously in the same computerized environment. Item-id (2) is a unique number identifying a component object.

Component object "glibc" is the standard library used by multiple programs on the Linux system. Component object "libc" is an older version of "glibc" used by applications in the older Linux systems.

Component objects "glibc6.0", "glibc6.1", "libc2.0" and "libc2.1" are not allowed to operate simultaneously in the same computerized environment. The rule in human language is transformed by research module 54 using rule language module 58 of Fig. 2 into the rule language expression:

XOR (GLIBC6.0 OR GLIBC6.1 OR LIBC2.0 OR LIBC2.1)

The expression is a xor-rule comprising a XOR logical operator and a component choice-set. The component choice-set comprising a group of component object identifiers connected with the OR logical operator. Therefore the expression is consistent with the terminology of the rules language.

The expression is encoded and inserted into xor rules table 61 in the format shown in box 106. For the first entry, cond-index is set to the value of 1, which is an arbitrarily chosen identifier of the specific xor-rule. "Glibc6.0" is identified by the number 100 therefore the field item-id is set to the same number.

The next three entries belong to the same xor-rule therefore the value of the field cond-index is replicated. 101 representing "glibc6.1", 128 representing "libc2.0", and 129 representing "libc2.1" are inserted into the field item-id of the second, third and fourth entries respectively. The XOR and OR operators are assumed as every xor-rule set comprises a XOR and an OR operator by definition. In box 108 there is shown the detailed underlying logical syntax of the xor-rules table.

Consequently when a virtual installation of a specific component object will be attempted, conflict resolver module 39 of Fig. 1 will interrogate xor rules table 61 as for the presence of the component object in any of the xor rules tables. If found the other component objects associated with the same xor rule are checked for in the original system information table and if any of them found the installation of the specific component object will be aborted.

Persons skilled in the art will appreciate that the present invention is not limited to what has been particularly shown and described hereinabove. Rather the scope of the present invention is defined only by the claims which follow.

I CLAIM:

1. In a computing environment running on a computer platform utilized as a central server system having a storage device, an I/O device, a communication device, and an operating system a method of system management support is operating in order to make available the capability for system managers of client system connectable thereto of performing an automatic or a semi-automatic software components upgrade process comprising:

gathering a plurality of information related to component objects from component object information sources;

researching said plurality of gathered information related to said component objects;

collecting said plurality of component objects researched from component object sources;

collecting a plurality of said component object-related component data to be used as component object information from component data sources;

storing said plurality of component objects to a component object database in said storage device of said central server system;

storing said plurality of component data to a component data database in said storage device of said central server system;

encoding the functional dependencies of said component objects into an abstract model representing inter-component dependency rules;

inserting said abstract model of inter-component dependency rules into a knowledge base;

validating said abstract model of inter-component dependency rules utilizing said knowledge base against said component objects;

thereby making available to system managers of client system connectable to said central server, to utilize said component object, said component data and said abstract model of dependency rules for the purpose

of installing, uninstalling or updating component objects on said client systems computing platforms.

2. The method of claim 1 of researching said information further comprising the steps of:

examining said component information;

scanning said component information;

analyzing said component information for interconnectedness, interrelationships, and interdependency rules;

indexing said component information according to component object types, component object version number and inter-component dependency rules;

organizing said component information into meaningful patterns of component data .

3. The method of claim 1 of storing said component data further comprising the steps of:

inserting specific component data according to attributes observed by said researching into a specific component data structure on the storage device of said central server system;

inserting said dependency rules observed by said researching of component information into specific rules tables on said storage device of said central server system;

creating update modules related to specific component objects to be utilized in said computer object installation process and inserting said update modules into specific update module data structures on said storage device of said central server system.

4. The method of claim 1 of encoding the functional dependencies of said component objects further comprising the steps of:

determining the relations among said component objects;

determining the order of hierarchy among component objects;

determining whether component objects need other component objects in order to operate correctly in the same computing environment;

determining whether component objects are unable to operate with other component objects in the same computing environment.

5. The method of claim 1 of further comprising the steps of:

querying said knowledge database;

allowing said system managers to download said component object, said component data and said dependency rules to said client system platforms;

setting preferences regarding said installation, uninstallation, and updating of specific component objects operating in said computing environment of said client systems;

utilizing downloaded said component data and said dependency rules in order to perform a software system configuration simulation;

utilizing downloaded component objects and the configuration files resulting from said software system configuration simulation to perform a software system upgrade.

6. The method of claim whereby said dependency rules are encoded and stored by utilizing a specific rules language.

7. The method of claim 1 further comprising the step of producing inter-component dependency conflict-free configuration by said software system upgrade simulation that utilizes said component data and said dependency rules.

8. The method of claim 1 further comprising requesting notifications from said central server concerning new component objects or new versions of existing component objects by said system managers.

9. The method of claim 1 further comprising requesting automatic downloading of said new component objects or said new versions of existing component objects to said computer platform running said client system by said system managers.

10. A system of virtual system configurator operating in a computing environment on a central server system platform having a storage device, an I/O device, a communication device, an operating system, and virtual system configuration system comprising:

a knowledge database to hold said component data collected from said component data sources and said dependency rules produced by said researching of said component information;

a component object database to hold said component objects collected from said component object sources;

a user preferences table to hold user preferences regarding automatic downloading of said component objects, automatic notifications of said new component objects or said new versions of existing component objects;

a rules language module to handle the encoding and decoding of said component objects dependency rules;

a component object and component data input module to retrieve said component objects and said component information;

a component object validation module to test said abstract model of said component objects relationships and dependencies;

an auto-download module to export said specific component objects to said client systems by said system managers request;

an auto-notify module to transmit automatic notifications concerning said component information to said client systems by said system managers request;

a client requests module to handle said system managers requests;

a client preferences module to create, update and maintain said client preferences table;

a client queries and updates module to handle said clients queries concerning said component information and to handle said clients request concerning automatic downloading and notification;

and a knowledge base handler module to handle said downloading of said dependency rules, said component data and said update modules to said client systems by requests of said system managers.

11. The system of claim 10 of said knowledge database further comprising:

a version tree to hold said component data organized in meaningful patterns regarding hierarchical relationships among component objects;

an xor (exclusive or) or (not exclusive or) rules table to hold said dependency rules among said component objects regarding capability of different component objects to operate correctly with other component objects in the same computing environment;

and an add-remove rules table to hold said dependency rules among said component objects concerning the necessity of said component objects to other component objects to operate correctly in the same computing environment;

a link table to provide links between different records of said version tree in order to connect groups of component data to accomplish correct updating of component objects in said virtual upgrade process;

a rule stamps table to hold a list of time stamp types to differentiate between the type of time stamp updates of said component data and said dependency rules encoded;

a stamp table to hold a historical list of said time stamps applied to records of said version tree to distinguish between the different versions of records in said version tree;

an update module table to the to an installation script file to be used during said installation, said uninstallation, and said update process of said component objects.

12. The system of claim 10 of said knowledge database further comprising representations of abstract component types to be used as types and subtypes of said component objects.

13. The system of claim 10 of said knowledge database further comprising installable component types data to be used for said installation, said uninstallation and said updating of said component objects.

14. The system of claim 10 of said knowledge database further comprising of useful data fields like a pointer to said installation script type, a version number, a release number, a description, and a time stamp.

15. The system of claim 11 of said xor rules table further comprising a rule index to identify the type of said xor rule and component objects identifying indices to point to said component objects data in said version tree.

16. The system of claim 11 of said add-remove rules table comprising a component object identification index to point to said component object data which needs other components to operate correctly in the same environment.

17. The system of claim 11 of said add-remove rules table further comprising of a group index to point to a group of component object indices to indicate component objects needed by said component object which needs other component objects to operate correctly in said same computing environment.

18. The system of claim 11 of said add-remove rules table further comprising of component object indices to point to said component objects data in said version tree that are needed by said component object which needs other component objects to operate correctly in said same computing environment.

19. The system of claim 11 of said add-remove rules table further comprising contrary rules to indicate the said component object that needs other component objects might not need a specific component object to operate correctly in said computing environment.

20. The system of claim 10 of said rules language module further comprising definitions of dependency relationships between two or more said component objects in terms of distinct component objects, component objects choice-sets, rules sets, need-rules sets, and xor rules-sets utilizing logical operators and dependency operators.

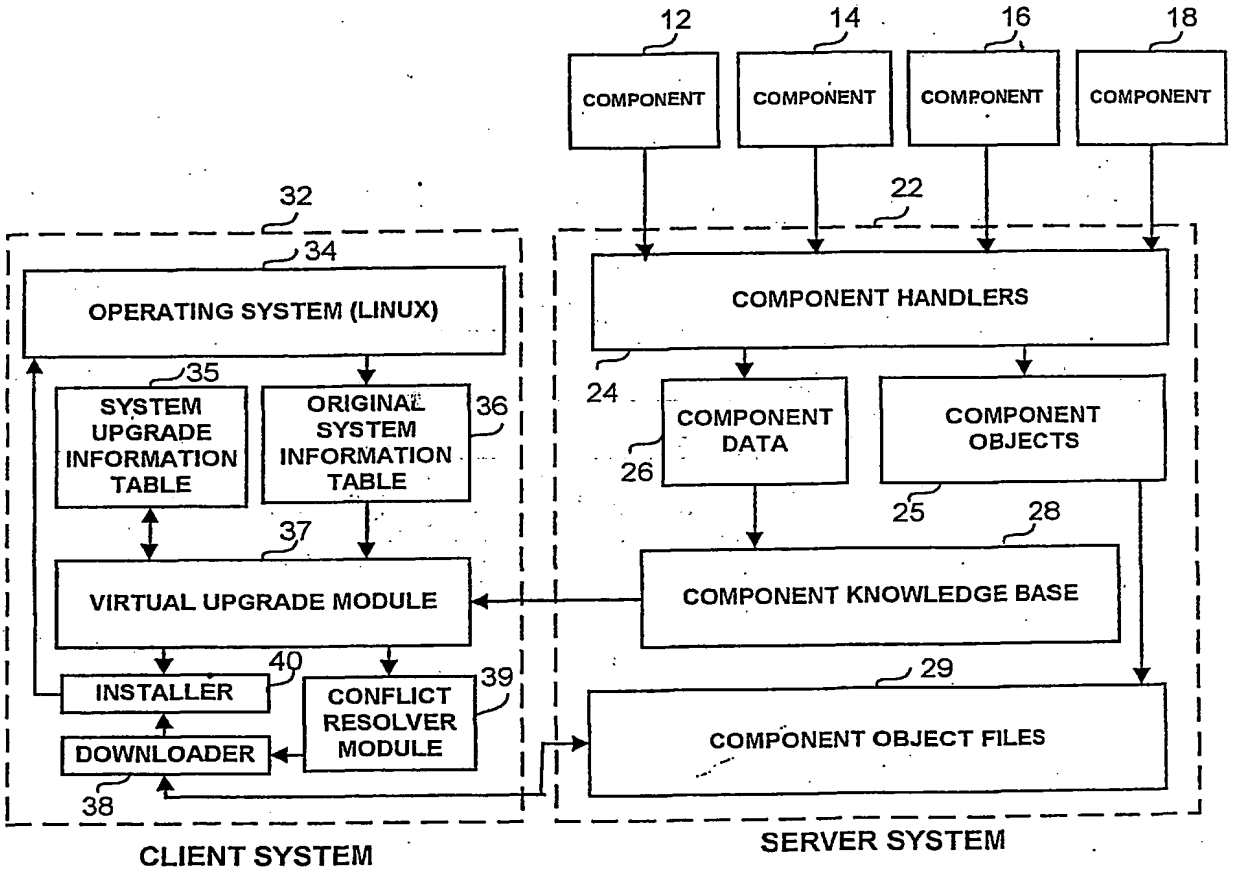

12
14
16
18
COMPONENT
COMPONENT
COMPONENT
COMPONENT
32
22
34
OPERATING SYSTEM (LINUX)
COMPONENT HANDLERS
35
SYSTEM UPGRADE INFORMATION TABLE
ORIGINAL SYSTEM INFORMATION TABLE
36
24
COMPONENT DATA
COMPONENT OBJECTS
26
25
28
37
VIRTUAL UPGRADE MODULE
COMPONENT KNOWLEDGE BASE
40
39
INSTALLER
CONFLICT RESOLVER MODULE
29
DOWNLOADER
COMPONENT OBJECT FILES
38
CLIENT SYSTEM
SERVER SYSTEM

FIG. 1

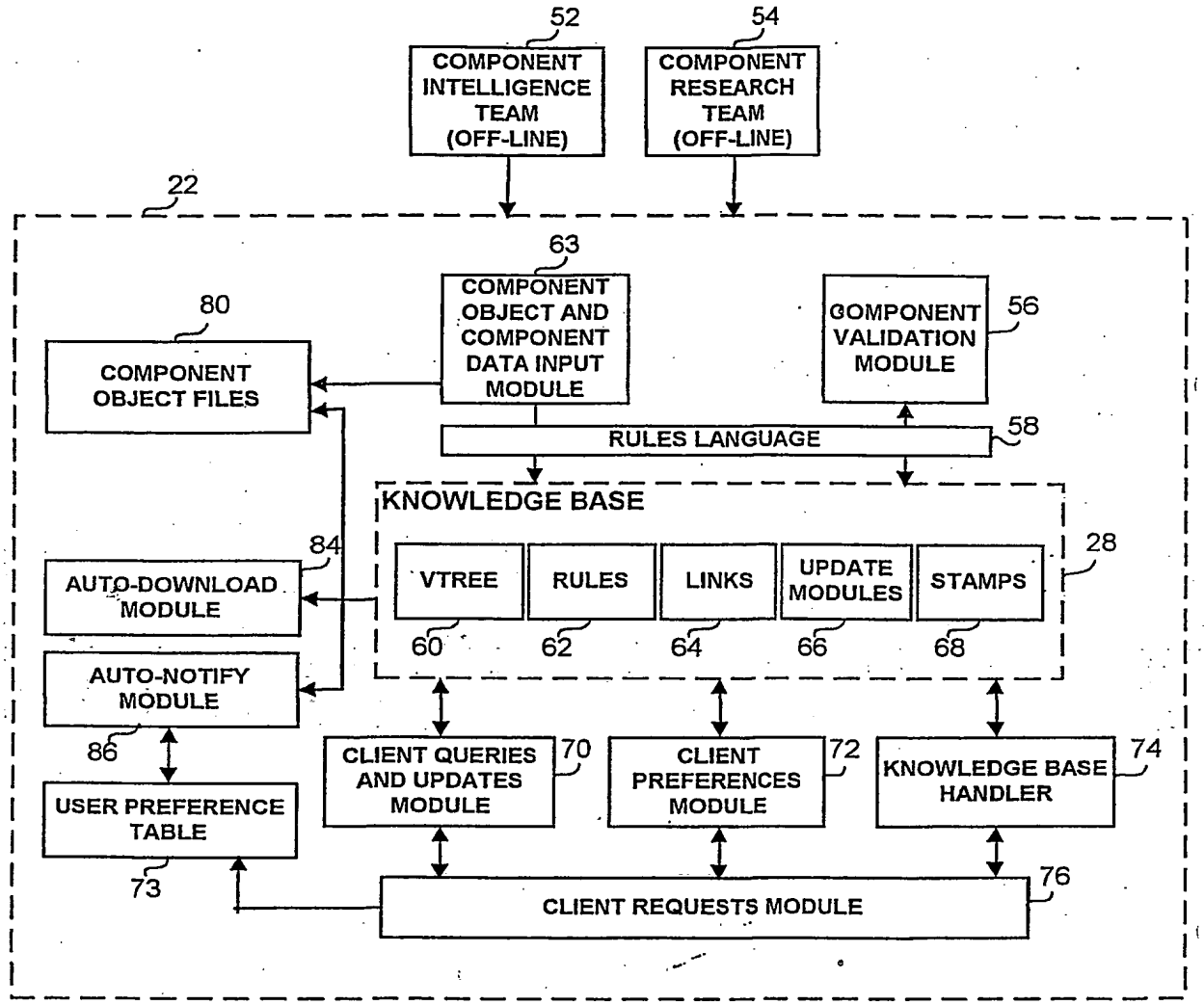

52
54
COMPONENT INTELLIGENCE TEAM (OFF-LINE)
COMPONENT RESEARCH TEAM (OFF-LINE)
22
63
COMPONENT OBJECT AND COMPONENT DATA INPUT MODULE
80
COMPONENT OBJECT FILES
COMPONENT VALIDATION MODULE
56
RULES LANGUAGE
58
KNOWLEDGE BASE
28
84
AUTO-DOWNLOAD MODULE
VTREE
RULES
LINKS
UPDATE MODULES
STAMPS
60
62
64
66
68
AUTO-NOTIFY MODULE
86
CLIENT QUERIES AND UPDATES MODULE
70
CLIENT PREFERENCES MODULE
72
KNOWLEDGE BASE HANDLER
74
USER PREFERENCE TABLE
73
CLIENT REQUESTS MODULE
76

FIG. 2

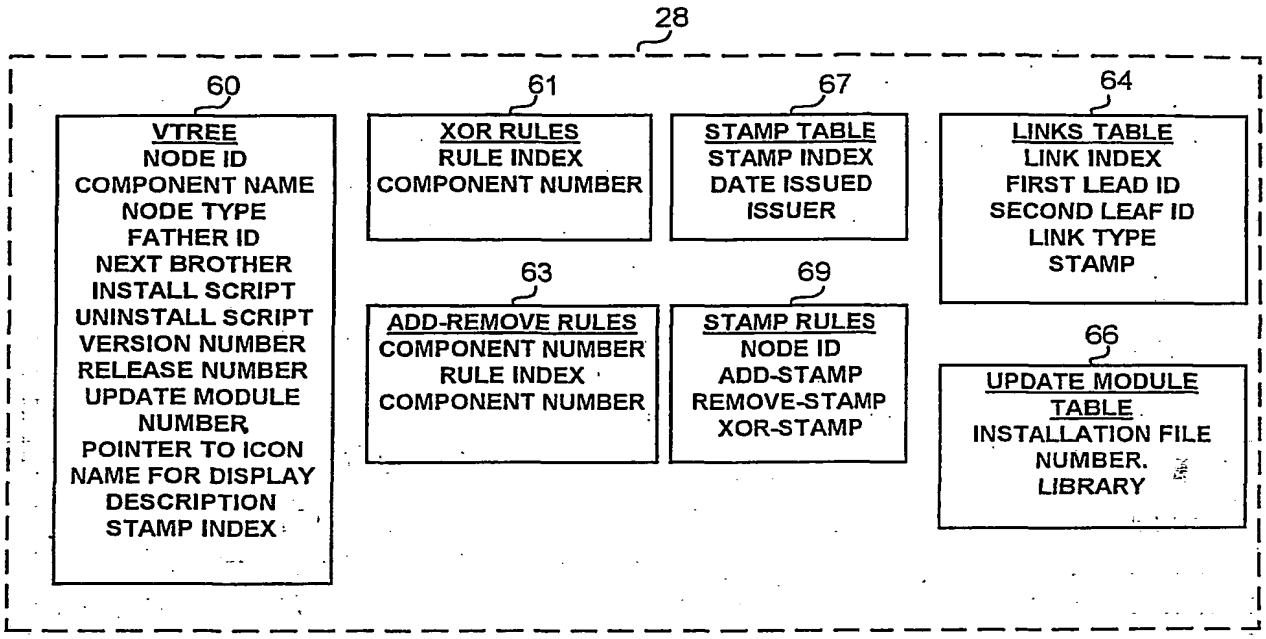

28
60
VTREE
NODE ID
COMPONENT NAME
NODE TYPE
FATHER ID
NEXT BROTHER
INSTALL SCRIPT
UNINSTALL SCRIPT
VERSION NUMBER
RELEASE NUMBER
UPDATE MODULE NUMBER
POINTER TO ICON
NAME FOR DISPLAY
DESCRIPTION
STAMP INDEX
61
XOR RULES
RULE INDEX
COMPONENT NUMBER
63
ADD-REMOVE RULES
COMPONENT NUMBER
RULE INDEX
COMPONENT NUMBER
67
STAMP TABLE
STAMP INDEX
DATE ISSUED
ISSUER
69
STAMP RULES
NODE ID
ADD-STAMP
REMOVE-STAMP
XOR-STAMP
64
LINKS TABLE
LINK INDEX
FIRST LEAD ID
SECOND LEAF ID
LINK TYPE
STAMP
66
UPDATE MODULE TABLE
INSTALLATION FILE NUMBER.
LIBRARY

FIG. 3

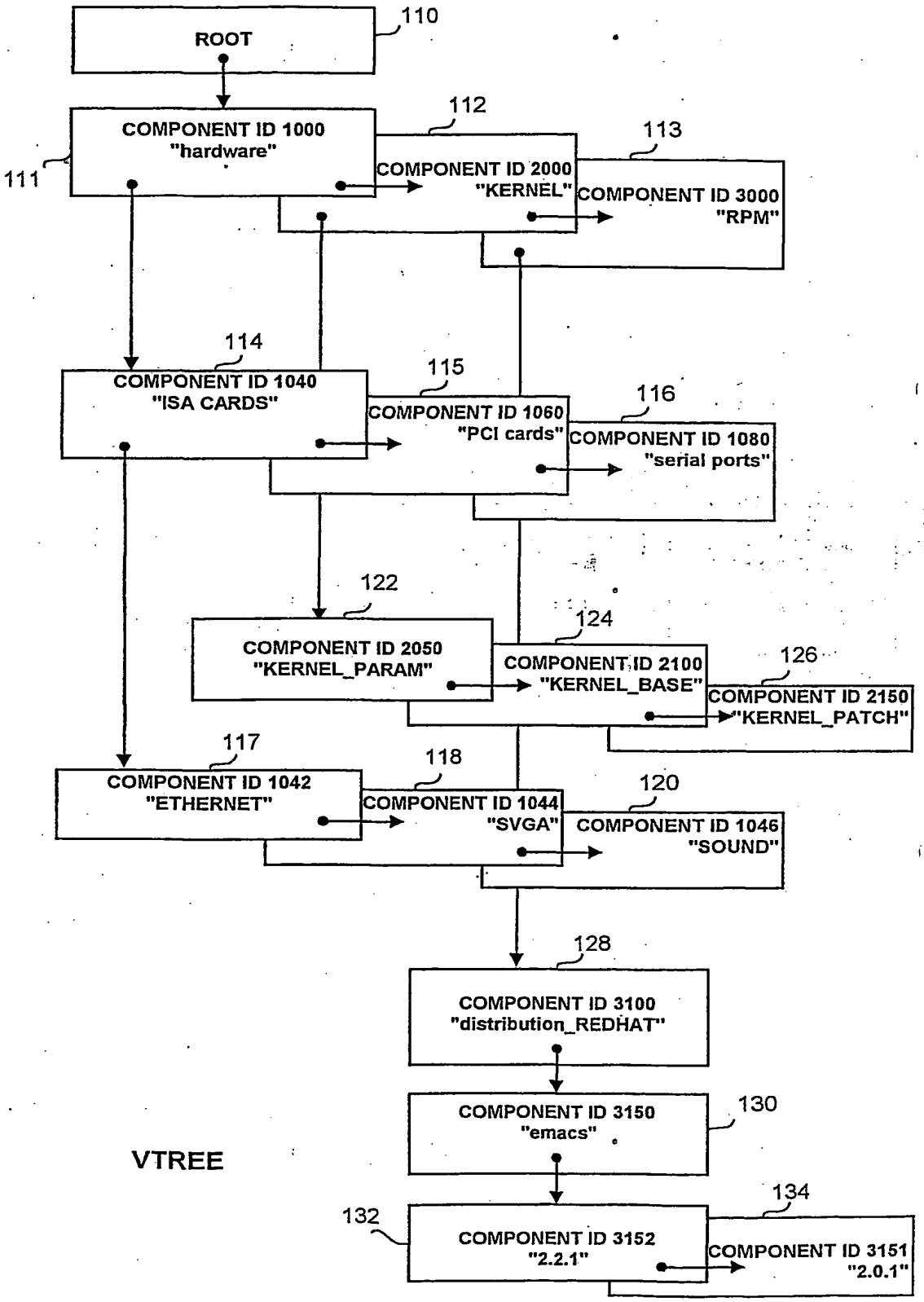
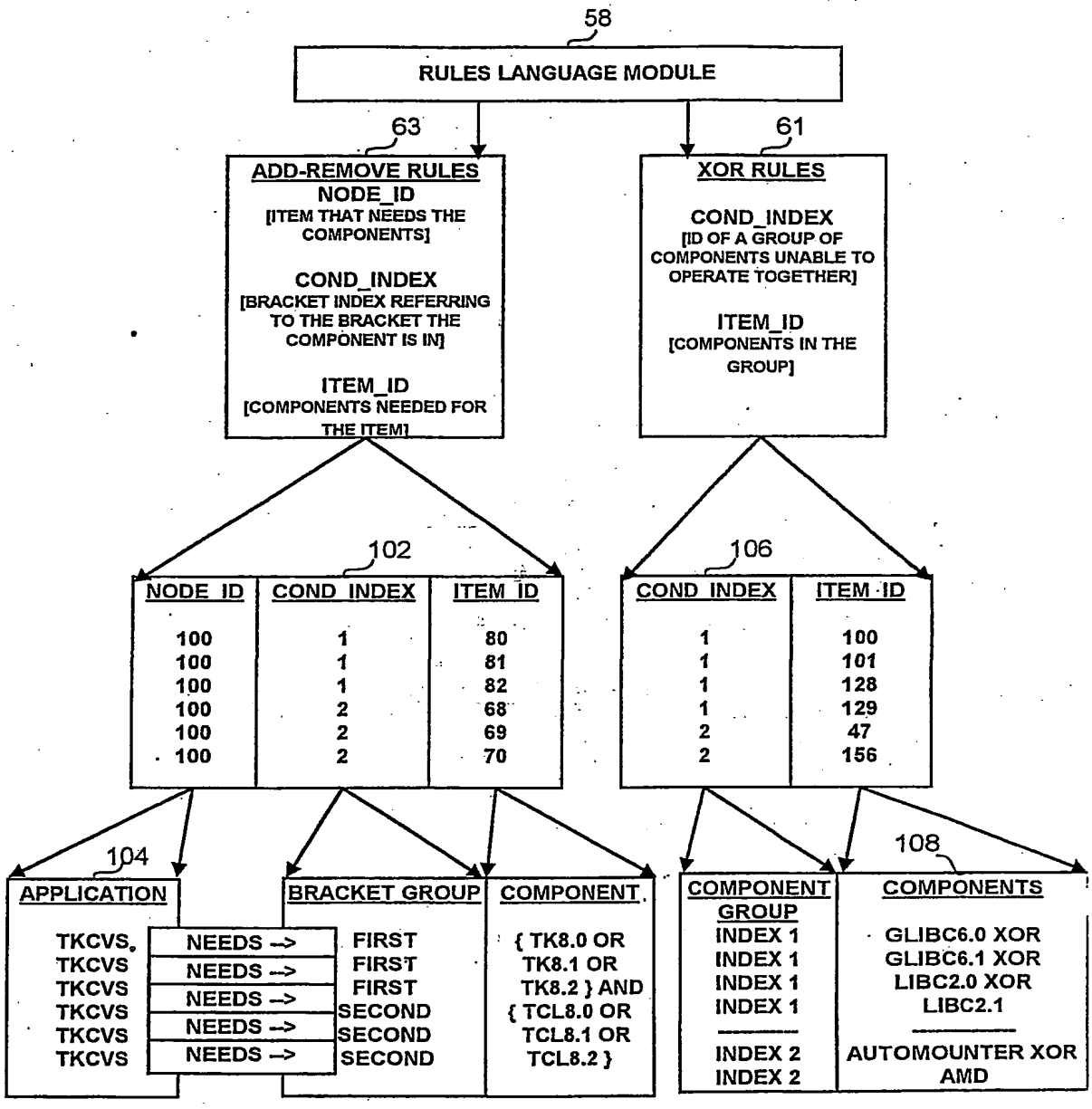

ROOT
110
COMPONENT ID 1000
"hardware"
111
112
COMPONENT ID 2000
"KERNEL"
113
COMPONENT ID 3000
"RPM"
114
COMPONENT ID 1040
"ISA CARDS"
115
COMPONENT ID 1060
"PCI cards"
116
COMPONENT ID 1080
"serial ports"
122
COMPONENT ID 2050
"KERNEL_PARAM"
124
COMPONENT ID 2100
"KERNEL_BASE"
126
COMPONENT ID 2150
"KERNEL_PATCH"
117
COMPONENT ID 1042
"ETHERNET"
118
COMPONENT ID 1044
"SVGA"
120
COMPONENT ID 1046
"SOUND"
128
COMPONENT ID 3100
"distribution_REDHAT"
COMPONENT ID 3150
"emacs"
130
VTREE
132
COMPONENT ID 3152
"2.2.1"
134
COMPONENT ID 3151
"2.0.1"

FIG. 4



RULE TABLES

FIG. 5